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(54) Wet-wipe maintenance device for a full-width ink jet printer.

(57) A full-width ink-jet printer comprises a printhead (14) defining in a surface an array of nozzle (22) openings for the emission of ink droplets therethrough. A shuttle (50) is adapted to travel on a track (52,56) through a fixed path generally parallel to the array. Mounted on the shuttle (50) are an applicator (60) for applying a liquid to the nozzle (22) openings and a vacuum device (62) for applying suction to the nozzle openings.

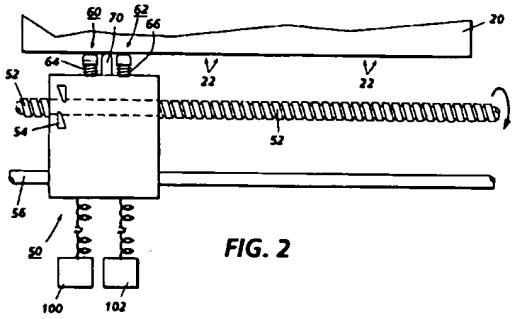

FIG. 2

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The present invention relates to ink-jet printing, and is more particularly concerned with an effective liquid applicator/vacuum device for cleaning contaminants from a full-width array ink-jet printhead.

In existing thermal ink jet printing, the printhead typically comprises one or more ink ejectors, such as disclosed in US-A-4,463,359, each ejector including a channel communicating with an ink supply chamber, or manifold, at one end and having an opening at the opposite end, referred to as a nozzle.

In a single-color ink jet printing apparatus, the printhead typically comprises a linear array of ejectors, and the printhead is moved relative to the surface of the print sheet, either by moving the print sheet relative to a stationary printhead, or vice-versa, or both. In some types of apparatus, a relatively small printhead moves across a print sheet numerous times in swaths, much like a typewriter; alternatively, a printhead which consists of an array of ejectors and extends the full width of the print sheet may be passed once down the print sheet to give full-page images, in what is known as a "full-width array" (FWA) printer. When the printhead and the print sheet are moved relative to each other, imagewise digital data is used to selectively activate the thermal energy generators in the printhead over time so that the desired image will be created on the print sheet.

With any kind of ink-jet printer in which a printhead is in close and extended contact with a substrate such as a sheet of paper with partially-dried ink thereon, an important practical concern is contamination of the area around the ejectors. External debris such as lint or stray paper fibers are likely to become caught in the small gap between the front face of the printhead and the sheet, possibly entering the nozzles of the ejectors and causing a failure of ejectors. Another cause of failure of individual ejectors is the fact that, if a particular ejector is not used for an appreciable length of time, even while the system is printing a document, a "viscous plug" of partially-dried ink will, in effect, cause a clot in the particular ejector, causing the ejector to fail at least temporarily, at least until the reheating of the particular ejector softens the viscous plug. A viscous plug often creates a partial blockage of an ejector, causing an ink droplet ejected therefrom to be misdirected. In ink-jet printers, a failure of even one ejector will have conspicuous results on a print, because the plugged ejector will leave a blank stripe across a printed area where the ink from the ejector should have been placed. Thus, the failure of even a very few ejectors in a system will render the entire system unsatisfactory to a demanding user. Therefore proper cleaning and maintenance of the area around the ejectors and between the ejectors and the substrate is of crucial importance to a practical ink-jet printer.

In a FWA printer, a generally different architecture is required to perform an effective cleaning of the printhead. Simply to wipe across the linear array in the direction the linear array is extending tends to be unsatisfactory because, with such a long wiping difference, contaminants removed from one end of the array will tend to be merely pushed to the nozzles on the other end of the array; i.e., with a long wiping distance, contaminants will tend to be simply moved from one ejector to another. What is needed is a maintenance station and FWA ink-jet printer which may rapidly clean across a long array without causing contaminants to be simply moved from one side of nozzles to another.

US-A 5,084,712 discloses a maintenance system for an ink jet printer, including a solvent supply system for spraying solvent on the faces of the ink-jets and in the ink-jet openings, and a brush for scrubbing the ink-jet faces during and immediately after the spraying process. The solvent vapors enter the jets and deprime the jets so that the ink remaining in the jets drains out back into an ink reservoir.

US-A 5,184,147 discloses an ink-jet printhead maintenance system having means for applying a vacuum to the ink-jet nozzles in the printhead. An elongated wiper engages and wipes the surface of the nozzles and is preferably moved at an extremely slow rate across the surface to enhance the wiping operation. A specialized drip edge is positioned beneath the orifice surface for directing drops of ink away from the ink-jet printhead which are generated during the cleaning procedure.

According to the present invention, there is provided an ink-jet printer comprising a printhead defining an array of nozzle openings in a surface, the array extending in a main direction for the emission of ink droplets therethrough; a shuttle for applying a liquid to a nozzle opening; and a track, adapted to support the shuttle thereon for movement in a path generally parallel to the main direction of the array to apply liquid to one or more nozzle openings in the array.

According to another aspect of the present invention, there is provided a method of maintenance for a printhead having a surface defining an array of nozzle openings for the emission of ink droplets therethrough, the array of nozzle openings extending in a main direction, comprising the steps of: (a) providing a shuttle having an applicator for applying a liquid at a predetermined pressure into a nozzle opening, and/or a vacuum member for applying suction to a nozzle opening; (b) and moving the shuttle in a direction generally parallel to the main direction of the array of nozzle openings while applying suction and/or liquid to a series of nozzle openings in the array.

Where step (b) comprises applying liquid, the method may comprise the step (c), before or after step (b), of moving the shuttle in a direction generally parallel to the main direction of the array of nozzle openings while applying suction only to the series of nozzle openings in the array.

Preferably, the method comprises moving the shuttle in a first direction while applying suction only to the series of nozzle openings in the array, and in an opposite direction while applying suction and liquid to the series of nozzle openings in the array.

Preferably, the step of applying suction comprises applying sufficient suction to remove a pre-determined quantity of ink from the or each nozzle opening.

According to still another aspect of the present invention, there is provided a method of maintaining a printhead having a surface defining an array of nozzle openings for the emission of ink droplets therethrough, the array of nozzle openings extending in a main direction. A shuttle is provided, the shuttle having an applicator for applying a liquid at a predetermined pressure into a nozzle opening, and a vacuum orifice for applying suction to a nozzle opening. The shuttle is moved generally parallel to the main direction of the array of nozzle openings while applying suction to a series of nozzle openings in the array. The shuttle is again moved generally parallel to the main direction of the array of nozzle openings while applying liquid to the series of nozzle openings, and also while applying suction to the series of nozzle openings in the array.

According to still another aspect of the present invention, there is provided a method of maintaining a printhead having a surface defining an array of nozzle openings for the emission of ink droplets therethrough, the array of nozzle openings extending in a main direction, the nozzle openings being adapted to retain liquid ink therein at a predetermined backpressure. A shuttle is provided, the shuttle having a vacuum member for applying suction to a nozzle opening without contacting the surface. The shuttle is moved generally parallel to the main direction of the array of nozzle openings while applying suction to a series of nozzle openings in the array.

The invention further provides a printhead maintenance apparatus for carrying out the method of claim 10, or any of the above-mentioned particular embodiments.

Embodiments of the invention will now be described, by way of example, with reference to the following drawings, in which:

Figure 1 is an elevational view showing the elements of a full-width array thermal ink-jet printer with which the present invention is suitable for use;

Figure 2 is a plan view showing a maintenance device according to the present invention interacting with the printhead of a full-width array ink-jet printer;

Figure 3 is a perspective view showing in isolation significant elements of a maintenance device according to the present invention; and

Figure 4 a sectional elevational view of a wet wiper according to the present invention.

Figure 1 is an elevational view showing a thermal ink-jet printer having a full-width linear array of ejectors which extend across the width of a sheet S moving through the system in process direction P. In the view of Figure 1, the linear array of ejectors extend into the page. There is provided in this embodiment of the printer an ink supply cartridge generally indicated as 10, which is mounted on a carriage 12. The cartridge 10 is preferably removably mounted in carriage 12 for the replacement thereof when the ink in the cartridge 10 is expended. The bulk of cartridge 10 is an ink supply generally indicated as 14, which in the embodiment shown is of a single color in one chamber, but one skilled in the art will appreciate that multiple chambers may be provided within cartridge 10 to facilitate the supply of multiple colors to the printer. The other important portion of cartridge 10 is the printhead, generally indicated as 20. Printhead 20, in a full-width array printer, comprises at least one linear array of selectively-actuable ejectors, (only one of which is shown in this end-on view) which are controlled by a series of leads thereto to a controller 30, which will activate the various ejectors in printhead 20 in accordance with image data during the printing operation. Each ejector in printhead 20 includes an ink channel 22 which terminates in an opening at the outer portion of the printhead through which ink is ejected. Adjacent each channel 22 is a heating element 24 which, when voltage applied across it, causes the rapid heating of liquid ink in the channel 22, causing the liquid ink to be ejected out of the printhead 20 and onto the sheet A new supply of ink is introduced into an individual channel 22 as needed through an ink supply manifold 26, which is connected through various means to one of any number of ink supply chambers in the ink supply 14, depending on the desired color of ink to be emitted from the particular channel 22. The various heating elements 24 for each ejector in the linear array are connected, by serial, parallel, or a combination of parallel and serial means, to a bus 28 which is ultimately connected to a controller 30 for the operation thereof to create an image on the sheet.

The embodiment shown in Figure 1 shows the carriage 12 holding cartridge 10 in such a position that the cartridge 10 is in its non-printing or "maintenance" mode. This is the position of the cartridge 10 so that the printhead 20 thereof is not directed toward the sheet S, but rather directed away so that ink in any of the channels 22 will not leak onto the sheet or, if there is no sheet in the printer, into the machine in general when the system is idle. When printing is desired, carriage 12 pivots, about pivot 13, to direct the printhead 20 toward the sheet S. During the printing operation, sheet S is typically moved in a continuous fashion across the printhead 20 by means such as rollers 40, actuated by a motor (not shown). Coordination of the operation of the printhead 20 by controller

30 with the position of the particular sheet S through the printer will be apparent to one skilled in the art.

Of course, if a multi-color printer is contemplated, there will typically be provided a plurality of parallel linear arrays of ejectors in the printhead 20, the ejectors in each array being connected to a particular color ink supply within the cartridge 10. Further, in various systems there may be provided multiple types of inks of the same color but of different drying rates, as would be required for a particular architecture. There may also be provided within the system, downstream of the printhead 20 in process direction P, any of various means to enhance or increase the rate of the drying of ink placed on the sheet, thereby to prevent smearing of the image as the sheet moves further along the system. Typical drying means may include convection or radiant heaters, a microwave device, or a light-flash device.

Figure 2 is a plan view of the relevant portions of the printer, showing how a maintenance station of the present invention is used to clean the front face of printhead 20. The basic elements of the present invention include a shuttle generally indicated as 50, which travels along a rotating lead screw 52, which is typically caused to rotate axially by means of a motor (not shown). As lead screw 52 rotates, a structure such as fingers 54 located on the shuttle will cause the shuttle to move longitudinally as the fingers 54 interact with the threading on lead screw 52. Shuttle 50 may also include means for engaging a guide rail 56, which in this embodiment is a smooth rail which serves to maintain the rotational position of the shuttle 50 relative to the lead screw 52, ensuring that the shuttle 50 does not rotate with the lead screw when the lead screw 52 is rotated. In this way, lead screw 52 and guide rail 56 function as a "track" by which the shuttle 50 may be moved in a predetermined path generally parallel to the face of the full-width printhead 20, when the carriage 12 is holding printhead 20 in the maintenance position.

Mounted on shuttle 50 and disposed to engage the front face of printhead 20, and specifically to engage the nozzle openings of the ink channels 22 of the printhead 20 are a wet wiper 60 and a vacuum nozzle 62. Wet wiper 60 and vacuum nozzle 62 are so disposed relative to the channel 22 in printhead 20 that, when shuttle 50 is caused to move by lead screw 52 across the front face of printhead 20, both the wet wiper 60 and vacuum nozzle 62 will be caused to slide against the nozzles of the channels 22 in printhead 20. In order to maintain a degree of contact between the wet wiper 60 and the vacuum nozzles 62 and the printhead 20, the wet wiper 60 and vacuum nozzle 62 may be gently urged, such as by coil springs 64 and 66, respectively, against the front face of printhead 20.

The purpose of wet wiper 60 is to apply a predetermined amount of cleaning liquid, such as water, to the front face of the printhead 20, and to re-prime (i.e., replenish the liquid ink supply) within the channels 22 of printhead 20. In turn, the purpose of vacuum nozzle 62 is either to directly remove contaminants such as lint and paper fibers from the front face of printhead 20, or to act in conjunction with the wet wiper 60 to remove viscous plugs of partially dried ink from the channels in the printhead 20. The water or other liquid may be supplied by an on-board water source 100 of known design, and the vacuum may be supplied from an on-board vacuum source 102 of known design, both shown schematically in Fig. 2.

In the preferred method, the shuttle 50 is first moved across the printhead so that the vacuum nozzle 62 is first in the direction of motion. In this first pass across the printhead in the maintenance cycle, vacuum from the vacuum nozzle 62 is applied to the channels of the printhead in succession. This step, as mentioned above, is a good preliminary first step in removing larger particles such as lint and paper fibers from the front face of the printhead. Preferably, the vacuum through vacuum nozzle 62 is more than one order of magnitude greater than the typical negative pressure experienced by ink within a channel while a particular ejector is idling. The preferred range for the vacuum at the vacuum nozzle is about 4-10 PSI (27.6-69kPa) at the nozzle tip. The typical back-pressure for retaining ink within a channel 22 in the printhead 20 is between about -0.03 and -0.15 PSI (0.21 and 1.04 kPa). In this initial vacuuming step, it is acceptable that the vacuum nozzle 62 remove 10-20 channel-length volumes of ink, or about 0.002-0.004 microliters of material from each channel to clean the channel. In this way, every ejector in the full-width printhead will be thoroughly cleaned of viscous plugs.

After the shuttle 50 has moved across the printhead 20 one time, according to the preferred method of the present invention, the direction of shuttle 50 is reversed, such as by reversing the direction of rotation of lead screw 52 in the illustrated embodiment, so that the shuttle 50 moves across the linear array of ejectors in printhead 20 with the wet wiper 60 first. As wet wiper 60 moves across the front face 21 of printhead 20, the wet wiper 60 applies a small quantity of water (from a source not shown) to the front face of the printhead. According to a preferred embodiment of ink-jet printheads, the front face 21 of printhead 20 is a hydrophobic surface, preferably fluorinated carbon DLC ("diamond-like coating"), which will cause the applied water to bead on the front face. Basically, the wet wiper 60 is in the form of a wick having enough outward pressure thereon to cause a small quantity of water to bridge from the wet wiper 60 to the front face of the printhead 20, without causing undue "weeping" of excess water into the system in general. A preferred range for outward water pressure from the wet-wiper 60 for meniscus wiping is between about 0.015 and 0.075 PSI (0.104 and 0.518

kPa). This water serves a number of purposes. First, the small amount of water imparted to the printhead 20 by the wet wiper 60 restores a necessary amount of relative humidity to the area around the channels. This relative humidity is helpful in, for example, decreasing the likelihood of viscous plugs of dried ink forming too soon within the channels. Further, the water may have diluted therein a relatively small amount of a detergent, which may be useful in removing certain kinds of dirt and other debris from the area around the channels. Of course, following the application of liquid on the "return trip" of the shuttle 50, the printhead 20 is almost immediately vacuumed again through vacuum nozzle 62. Once again, this step of the preferred method is helpful in restoring the "prime" of available liquid ink within the channels immediately before the printing of a job.

Ink and other contaminants collected through the vacuum nozzle 62 may be separated from an air flow through known means, such as a separation chamber within the apparatus.

Figure 3 is a perspective view of wet wiper 60 and vacuum nozzle 62 as they face the printhead 20. The structure of wet wiper 60 will be discussed in detail below. Generally speaking, typical diameters for the wet wiper 60 and the vacuum nozzle 62 are from one-quarter inch to one-half inch (6.35 to 12.7mm). There may also be included a follower 70, of comparable size and shape to the wet wiper 60 and vacuum nozzle 62, which is intended to engage an area adjacent the printhead 20, when the printhead 20 is in maintenance mode, to serve as a spacer for proper contact of wet wiper 60 and vacuum nozzle 62 to the area on the printhead 20 around the channels 22. Vacuum nozzle 62 is preferably in the form of a small dome having a slit-like orifice 72 defined therein and oriented to follow the direction of the linear array of ejectors in printhead 20. This orifice 72 is adapted to encompass a subset of nozzles in the array of the printhead at a given time as the shuttle 50 move across the entire array. The outer surface of vacuum nozzle 62, as well as of follower 70, is preferably of a low-friction plastic material, and, in particular, of Teflon® -impregnated Delrin A/F® (basically, Teflon fibers dispersed in acetal resin). In addition to or in lieu of spring-loading the wet wiper 60 and vacuum nozzle 62 separately, the wet wiper 60, vacuum nozzle 62 and follower 70 may be together molded on a single plastic plate such as 74, which may be springably mounted itself on the shuttle 50. The wet wiper 60 and vacuum nozzle 62 are connected to sources of vacuum or liquid supply through flexible tubing such as 61 and 63, respectively.

Figure 4 is a sectional elevational view of wet wiper 60 according to a preferred embodiment of the present invention. The main portion of wet wiper 60 comprises a wick 80 of urethane felt, which is reticulated and compressed within an outer tube 82. A preferred wicking material is a reticulated felted foam with a compression ratio of 4:1 made by Scott Inc. and sold under the trade name SIF Felt. At the effective tip of wet wiper 60 is provided a low-friction wiping member 84 which is preferably made of a mesh of hydrophilic nylon such as that made by Tetko Inc. and sold under the trade name Nitex®. Water from an external source (not shown) is supplied through the wicking felt 80 to create a slight positive pressure outward from the wet wiper 60 through the nylon mesh in tip 84. A ring 85, of metal or plastic, is useful for retaining the wiping member 84 on the tip.

The tip of the wet wiper 60 should be spaced 5 mils (127μm) or less from the front face of the printhead 20. It is preferred that the wet wiper 60 not be in any contact with the front face 21. Rather, it is intended that the outward pressure of liquid at the tip of the wet wiper 60 create a positive meniscus that "bridges" over to the front face 21. With this "cushion" of liquid between the wet wiper 60 and the front face 21, the wet wiper 60 may glide along the front face, wiping away contaminants and depositing liquid into the nozzle openings, while avoiding any solid-to-solid contact, which is likely to abrade and ultimately damage the front face of the printhead. The same spacing principle applies to vacuum nozzle 62: the trail of liquid that is left behind as the wet wiper 60 moves along the array may be effectively vacuumed off the front face 21 even when the vacuum nozzle 62 is not in actual contact with the front face 21. Again, the preferred spacing for the vacuum nozzle 62 is less than 5 mils (127μm) from the front face 21.

In a preferred operation of the present invention, the maintenance routine of causing the shuttle 50 to move back and forth once across the front face of the printhead 20 in the maintenance mode position is carried out at least after every job, and also perhaps at periodic intervals, for example, of one hour, when the machine is generally idling. One danger of using a thermal ink-jet printer with a large number of ejectors is that prolonged idling will increase the likelihood of partial evaporation of ink, causing viscous plugs to be formed in some of a large number of channels; by providing a periodic automatic maintenance routine, the integrity of the large number of ejectors may be preserved.

As a possible alternative to the solid, dome-shaped follower 70, there may also be provided as a follower a floating ball bearing to reduce friction toward portions of the printer adjacent the printhead face. This follower is useful in maintaining the desired spacing of the wet wiper 60 and vacuum nozzle 62 from the front face 21 of the printhead 20, particularly if the wet wiper 60, or vacuum nozzle 62, or both, are spring-loaded relative to the front face.

Claims

1. An ink-jet printer comprising:
   a printhead (14) defining an array of nozzle (22) openings in a surface, the array extending in a main direction, for the emission of ink droplets therethrough;
   a shuttle (50) for applying a liquid to a nozzle opening; and
   a track (52,56), adapted to support the shuttle (50) thereon for movement in a path generally parallel to the main direction of the array to apply liquid to one or more nozzle openings in the array.

2. A printer as in claim 1, wherein the shuttle comprises an applicator (60) adapted to provide pressurized liquid into the or each nozzle opening, preferably at a pressure of from about 0.015 to 0.075 PSI (0.104 to 0.518 kPa).

3. A printer as in claim 2, wherein the applicator is spaced apart from the surface during said movement, the applicator preferably being adapted to create a meniscus of liquid that bridges to the surface.

4. A printer as in claim 1, wherein the shuttle further comprises a vacuum member (62) for applying suction to one or more nozzle openings.

5. A printer as in claim 4, wherein the applicator and the vacuum member are disposed on the shuttle (50) in a direction substantially parallel to the main direction of the array.

6. A printer as in claim 5, wherein the shuttle is movable along said track alternately in a first direction, in which said vacuum member (62) is operative, and a second direction, opposite to said first direction, in which said applicator (60) is operative.

7. A printer as in claim 4, 5 or 6, further comprising means (64,66) for resiliently supporting the applicator (60) and the vacuum member (62) on the shuttle (50).

8. A printer as in any of the preceding claims wherein the printhead (14) is pivotable about an axis (13), parallel to said main direction, between a first position in which the printhead (14) is operable to emit ink droplets, and a second position in which the printhead is in facing relationship with said shuttle (50).

9. A printer as in any of claims 4 to 8, wherein the shuttle further includes a follower which is preferably adapted to maintain said applicator (60) and/or said vacuum member (62) spaced apart from said surface during said movement.

10. A method of maintenance for a printhead (14) having a surface defining an array of nozzle (22) openings for the emission of ink droplets therethrough, the array of nozzle openings extending in a main direction, comprising the steps of:
    (a) providing a shuttle (50) having an applicator (60) for applying a liquid at a predetermined pressure into a nozzle opening, and/or a vacuum member (62) for applying suction to a nozzle opening; and
    (b) moving the shuttle in a direction generally parallel to the main direction of the array of nozzle openings while applying suction and/or liquid to a series of nozzle openings in the array.

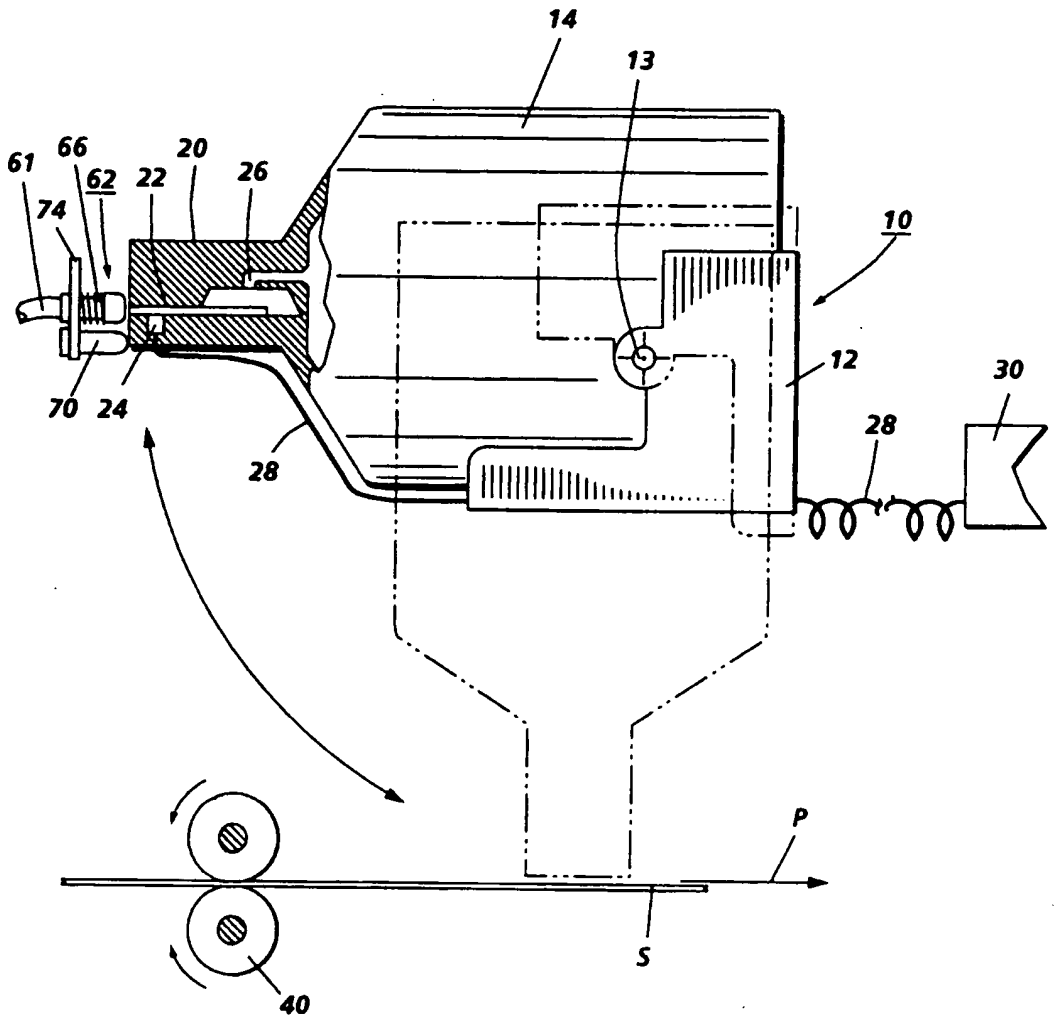

FIG. 1

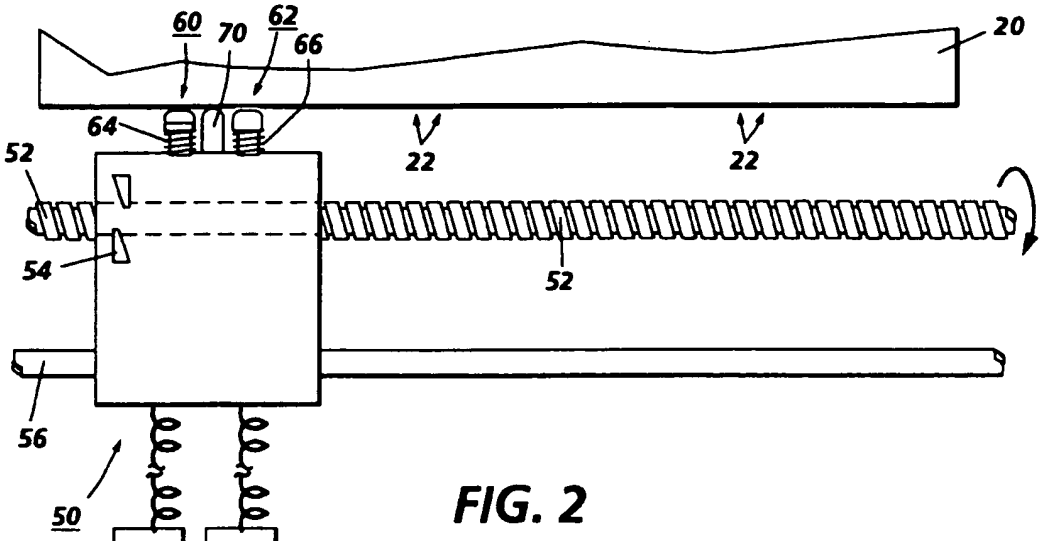

FIG. 2

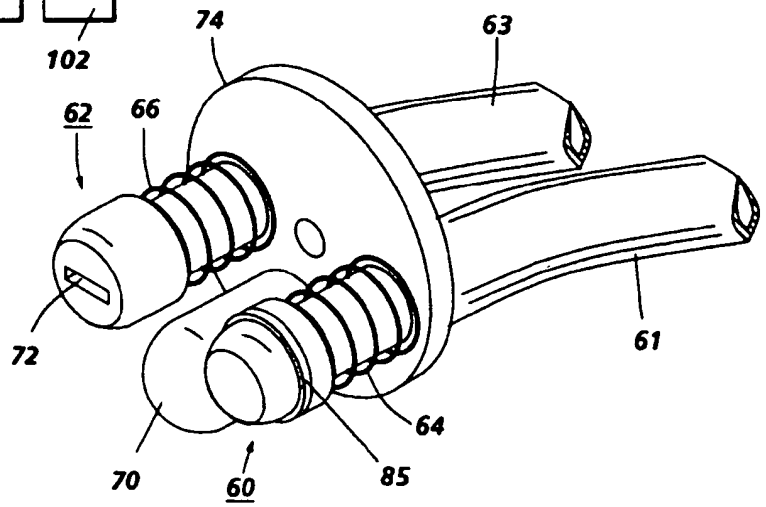

FIG. 3

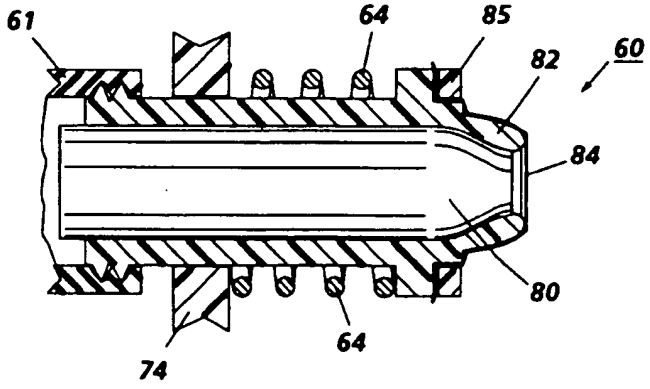

FIG. 4